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Drivers of catch and biodiversity around Western and Central Pacific Seamounts

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1. Abstract

Seamounts have been shown to be areas of ecological importance on a global scale (Pitcher et al., 2007). In particular, seamounts have been found to be hotspots of pelagic biodiversity, productivity and biomass (Morato et al., 2010a; Kvile et al., 2014). However, recent evidence has demonstrated that not all seamounts are areas where productivity, biomass and biodiversity of marine life thrive (Morato et al., 2010b; Kvile et al., 2014). The drivers of this heterogeneity among seamounts remains an unanswered question. Understanding the mechanisms underlying seamount productivity is a major research challenge for pelagic open-ocean fisheries which utilize these habitats (Clark et al., 2012). The incorporation of oceanographic data in analyses of catch around seamounts has been suggested as an important next step to shed further light on existing paradigms of seamount ecology. Persistent hydrographic features, such as oceanic fronts, have been recognized to enhance biological activity in the pelagic realm and to drive marine animal distributions and migration patterns (Scales et al., 2014). Oceanic fronts have also been posited to play a role in aggregating biodiversity around seamounts (Morato et al., 2015). However, the importance of oceanic fronts in driving aggregations of visiting animals on seamounts has not been rigorously tested yet. This new research into the dynamics of seamounts should: 1) help fisheries managers understand whether seamount aggregations may lead to hyperstability of catch rates caused by tuna shoaling behavior and maintain higher biomass during stock declines (as suggested by Morato et al., 2009); 2) provide vital information to improve fine-scale CPUE analyses for input into stock assessments; 3) inform future sampling regimes; and 4) provide information on how the pelagic ecosystem in the region is structured to improve SEAPODYM models. This new research into the dynamics of seamounts should: 1) assist WCPFC with inclusion of seamount and hyper-stability effects in their ongoing science activities; 2) provide information to improve fine-scale CPUE analyses used in WCPFC stock assessments and indicator analyses; 3) inform future observer sampling regimes; and 4) provide additional information to improve the accuracy of SEAPODYM models in estimating the fine-scale distribution of tuna.

2. Background

Citing concerns of potential higher catches of juveniles, species of special interest (e.g., sharks and marlins), and increased interactions with megafauna (e.g., turtles, seabirds and marine mammals), the 2006 WCPFC Seamount Research Planning Workshop report (WCPFC-SC2-2006/EB IP-5; Allain et al.,

2006) implemented a project to enhance "understanding of the ecology of seamounts in relation to pelagic fisheries in order to assess the need for, and utility of, seamount-specific management measures." The project set out to understand the impact of seamounts on aggregation and movement of pelagic species and the impact of pelagic fisheries on those seamount communities. Morato et al. conveyed the results of the project in a 2009 report (WCPFC-SC5-2009), which described the hypothesized "seamount effect" on both biodiversity and tuna catch. However, Morato et al. found that only 5-10% of the seamount areas within the region of interest show significantly higher CPUE values for at least one tuna species. The study also indicated that fishing in seamount areas may be responsible for an annual longline tuna catch of as much as 25 thousand tons, with an increasing proportion of catch coming from seamount areas in more recent years. Of note, much of this catch came from areas within national jurisdictions.

Through the results of the OFP seamount project and other recent work, it is now recognized that seamount characteristics, including their morphology and oceanographic context, affect patterns of biodiversity and production of resident and associated organisms (Morato et al., 2010b, 2015; McClain and Lundsten, 2015). However, the mechanisms that produce aggregations of fish and other marine predators around seamounts are still unclear (Kvile et al., 2014). Recent studies have called for the better elucidation of the processes driving seamount productivity, with a particular emphasis on the importance of examining the relationship between seamount productivity and local oceanographic processes (Clark et al., 2012; Morato et al., 2015).

Persistent oceanographic features, such as fronts, promote species aggregations at higher trophic levels (Scales et al., 2014). Oceanic fronts have also been implicated as factors influencing the distribution of commercial fish species (Klemas, 2013; Prants et al., 2014), including many tuna species in the Pacific (Sund et al., 1981; Zainuddin et al., 2006). Tuna migration patterns in the Pacific have also been tied to oceanic fronts generated by convergence zones (Jones, 1991; Polovina et al., 2001), including within WCPFC stock assessments (Hoyle et al., 2012). Further, fronts have been connected to higher catches across multiple regions (Laurs et al., 1984; Fiedler and Bernard, 1987; Reddy et al., 1995). However, the interaction of fronts and seamounts and the potential effect of the interaction in driving aggregations on seamounts remains unknown. Morato et al. (2015) provide a first step toward understanding the connection between fronts and seamounts and pelagic biodiversity, but could not provide a definitive answer due to the use of model results as data rather than the original catch data. In this project we seek to provide that answer and to understand whether seamount aggregations may lead to

hyperstability of catch rates caused by tuna shoaling behavior and maintain higher biomass during stock declines as suggested by Morato et al. 2009.

3. Study Objectives

The proposed study will take the next step in understanding why some seamounts aggregate tuna and pelagic biodiversity. We will model the influence of physical oceanography on the aggregation of tuna and pelagic biodiversity around seamounts using data from both pelagic longline fisheries and purse seine fisheries. The analyses will include distance from seamounts along with several metrics describing the strength and persistence of oceanic fronts in the region. We will draw comparisons between trends in catch rates around aggregating seamounts and those away from seamounts to address the question of hyper-stability in seamount catches, and provide vital information to improve fine-scale CPUE analyses for input into stock assessments for the region. The analysis will also inform future sampling regimes by identifying whether there is a need to focus biological sampling on the areas around seamounts. Lastly the model results should also improve SEAPODYM models by providing a better idea of how the pelagic ecosystem in the region is structured.

PHASE I *(Months 1 - 6)*: Stakeholder engagement, data aggregation & cleaning, and variable sampling

The study will commence with SPC surveying potential project participants regarding their interest and data holdings, and then compiling available data. SPC will then hold an initial workshop to gather participant's input, aggregate available data, agree on data descriptions and interpretations, and model formulation. Data confidentiality will be determined by the data owners and no results will be shown without review by all Parties who choose to contribute data.

During this phase, Duke University will work with SPC and IMAR to aggregate and clean longline and purse seine datasets, and standardize them as necessary. Plymouth Marine Laboratory will generate a time-series of sea-surface temperature (SST) front maps and chlorophyll-a front maps at as fine a resolution as is deemed useful and feasible (likely 1km), from which several metrics will be derived and sampled: frontal gradient magnitude and persistence; distance to nearest major front; and long-term monthly front frequency. Thermal and chlorophyll fronts often provide complementary information: the algae or suspended sediment acts as a tracer for physical processes, and hence may indicate fronts that only have a density gradient rather than a thermal gradient; in addition visible light is reflected back

from up to several meters into the water column, so it is possible to observe fronts that would be obscured in SST data by wind mixing, stratification or surface heating. Furthermore, we will identify convergent zones using Lagrangian Coherent Structure (LCS) techniques (d'Ovidio et al., 2004) applied to either geostrophic currents derived from satellite sea-surface height data, or to velocity fields derived from an assimilating global circulation model. Several researchers have related LCS structures to zooplankton or fisheries distributions (e.g. Prants et al., 2014). We expect that the development of a new seamount location database based on the SARAL/AltiKa Ka-band radar altimeter will be completed by researchers external to this grant during the first phase of this project and will be used in this new analysis. After the catch data is collated and cleaned, we will engage in sampling of environmental variables including distance to a seamount, distance to a front, and strength and persistence of SST and chlorophyll fronts.

PHASE II *(Months 6 - 18)*: Modeling

Duke University will lead model development, working with SPC and IMAR to test a number of regression models to determine which has the greatest utility to inform the question at hand. Likely analytical techniques will include random forests and generalized additive mixed effects models. Comparisons of catch rates around aggregating seamounts will be compared with other regions through permutations tests and/or test statistics.

PHASE III *Months (18-24)*: Evaluation of Management Strategies and Result Reporting

During this phase, we will produce a report addressing hyper-stability in seamount catches, and describing fine-scale CPUE analyses for input into stock assessments for the region to inform future sampling regimes and improve the SEAPODYM models. Peer-reviewed publications will also be developed to further elucidate the drivers of catch and biodiversity around seamount areas. In phase III, SPC will provide outreach to Parties and WCPFC Commission Members, Cooperating Non-Members, and Participating Territories (CCMs), regarding how the results of the study may inform fisheries management and marine spatial planning both within and beyond national jurisdictions. It is expected that findings from the study may be able to inform Pacific-wide bycatch management discussions as well as demonstrate methods and provide hypotheses to drive studies in other regions. We will endeavor to evaluate management strategies to examine the utility of various static and dynamic management

measures within the region to decrease bycatch around seamounts. The framework for these evaluations will follow Dunn et al. (2016).

4. Data Issues

It is anticipated that the study may be able to make use of otherwise confidential, nationally-held data (e.g. from observer programmes) in a secure environment. The success of this approach will depend on participants' data contributions being substantive and in a common format to facilitate their pooling into a joint database for analysis. Using the WCPFC Regional Observer Programme data as a starting point, SPC will seek permission from its members to incorporate any additional national observer data into a composite database for use under secure conditions. Other WCPFC and IATTC members which are not SPC members may also wish to contribute data to the analysis and in such cases SPC will negotiate data confidentiality arrangements with each participant as necessary. This study also hopes to make use of a new seamount dataset that has not been published yet. If that dataset is not available within the first 6 months of the project, we will revert to using previously available seamount datasets.

5. Funding Mechanism

We have an invitation to submit a proposal to the Lenfest Ocean Program to support this proposal. We have already presented the topic to them and received strong and favorable feedback. Funding and in-kind contributions may also come from the NF Nereus Program and the Fundação para a Ciência e Tecnologia (Portugal).

6. Desired recommendations by the WCPFC Scientific Committee

- Welcome the proposal
- Inclusion of this Research Project within the work programme of the SC
- To facilitate the access to WCPFC data holdings by project team members not employed by the Scientific Services Provider allocate a SC research project number
- Encourage all CCM's to collaborate and contribute national longline and purse seine datasets to the analyses (including relevant data from national observer programs).

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